U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

15.6.5 Appendix B RADIOLOGICAL CONSEQUENCES OF A DESIGN BASIS LOSS-OF-COOLANT ACCIDENT: LEAKAGE FROM ENGINEERED SAFETY FEATURE COMPONENTS OUTSIDE CONTAINMENT

REVIEW RESPONSIBILITIES

Primary - Accident Evaluation Branch (AEB)

Secondary - Effluent Treatment Systems Branch (ETSB)

I. AREAS OF REVIEW

A potential source of fission product leakage following a loss-of-coolant accident (LOCA) is the leakage of water from engineered safety features (ESF) equipment which is located outside the primary containment. Such leakage could occur during the recirculation phase for long-term core cooling and primary containment spray cooling. The fission products could then be released from the water into the atmosphere outside containment and, thus, result in offsite radiological consequences that contribute to the total dose from the hypothetical LOCA. To calculate the maximum leakage from recirculation loops following a hypothetical design basis LOCA, such sources as the following are considered: containment spray system, low pressure safety injection system, and high pressure safety injection system.

The review under SRP Section 15.6.5, Appendix B, includes the following:

(1) The types of postulated leakage from ESF components, including specifically, the leakage from valve stems and pump seals that can be expected during the operation of the ESF recirculation systems and the leakage from a postulated gross failure of an ESF passive component such as the failure of a pump seal.

(2) The design and operational features that are provided to mitigate the potential for radiological consequences from this transport path such as a leakage collection system, atmosphere filtration system, and technical specifications for ESF component leakage.

(3) The assumptions, model, and results of the dose calculations performed by the applicant for this fission product transport path. The staff performs

an independent analysis of the radiological consequences using conservative assumptions.

(4) An evaluation of the contribution of the radiological consequences of this transport path to the total radiological consequences from the hypothetical LOCA. The reviewer should perform this aspect of the review in conjunction with the evaluation of the total radiological consequences under SRP Section 15.6.5, Appendix A.

A secondary review is performed by the Effluent Treatment Systems Branch (ETSB) and the results are used by AEB in the overall review of the accident analysis. ETSB reviews the efficiency of the atmosphere filtration system to determine the iodine removal capability and the results are transmitted to AEB for use in the independent analysis.

II. ACCEPTANCE CRITERIA

The acceptance criteria are based on the requirements of 10 CFR Part 100 (Ref. 2) as related to mitigating the radiological consequences of an accident. Specific criteria necessary to meet this requirement are as follows:

(1) ESF systems that circulate water outside the containment are assumed to leak during their intended operation (e.g., valve stem leakage) and as a result of a failure of a passive component. Both types of leakage are included in the review. ESF atmosphere filtration systems should be provided in those areas where such leakage is postulated to occur in order to mitigate the radiological consequences from the fission product release.

(2) The radiological consequences from the postulated leakage should be calculated using conservative assumptions. 50% of the core iodine inventory, based upon the maximum reactor power level, should be assumed to be mixed in the sump water being circulated through the containment external piping systems, in accordance with the values listed in Table 1 of Regulatory Guide 1.7 (Ref. 1). The atmospheric dispersion factors (X/Q values) as determined under SRP Section 2.3.4 should be used in the analysis.

(3) The radiological consequences from ESF component leakage, as calculated by the staff, should be combined, under SRP Section 15.6.5 Appendix A, with the consequences from other fission product release paths to determine the total calculated radiological consequences from the hypothetical LOCA. The acceptability of the site, with respect to the total radiological consequences, is determined by the adequacy of the exclusion area and low population zone outer boundary distances in conjunction with the operation of dose-mitigating ESF systems. For operating license applications, the total doses should be within the exposure guidelines of 10 CFR Part 100, § 100.11 (Ref. 2) and for a construction permit application, the total doses should be within the guideline value of Regulatory Guides 1.3 (Ref. 3) and 1.4 (Ref. 4), as appropriate. This acceptability is determined under SRP Section 15.6.5, Appendix A.

III. REVIEW PROCEDURES

The reviewer selects and emphasizes aspects covered by this appendix as appropriate for a particular case. The judgment of which areas need to be given

attention and emphasis in the review is based on a determination if the material presented is similar to that recently reviewed on other plants and whether items of special safety significance are involved.

The applicant's recirculation leakage assumptions and calculation are compared with previously licensed plants for accuracy and completeness. It is assumed that 50% of the core iodine inventory, based upon the maximum reactor power level, is mixed in the sump water being circulated through the external piping systems (Ref. 1). Credit may be allowed for radioactive decay of the iodine during the time period from the occurrence of the LOCA up to the beginning of recirculation when the sump water is circulated outside the containment.

The leakage for calculating the radiological consequences should be the maximum operational leakage and should be taken as two times the sum of the simultaneous leakage from all components in the recirculation systems above which the technical specifications would require declaring such systems to be out of service. The leakage is assumed to occur throughout the accident, starting at the earliest time that the recirculation mode is initiated.

For a plant that does not provide an ESF atmosphere filtration system, the dose assessment should also include the leakage from a gross failure of a passive component. This leakage should conservatively be assumed to be 50 gallons per minute, starting at 24 hours after the accident and lasting for 30 minutes. For a plant that does provide an ESF atmosphere filtration system in the areas of potential leakage from a gross failure of passive components, such dose assessment need not be performed.

The applicant's information on the time-dependent temperature of the sump water circulating outside containment after the LOCA is evaluated. For a water temperature above 212°F, the fraction of the leakage that flashes to steam is determined assuming a constant enthalpy process. If the flash fraction is greater than 10%, then this fraction is taken as the fraction of iodine in the leakage that becomes airborne. If the calculated flash fraction is less than 10% or if the water is less than 212°F, then 10% of the iodine in the leakage is assumed to become airborne unless a smaller amount is justified based on actual sump pH history and ventilation rates.

The airborne iodine is assumed to be released immediately to the environment. The atmospheric dispersion is based upon the ground level X/Q values determined under SRP Section 2.3.4. Atmosphere filtration system filters are evaluated by the ETSB with respect to the guidelines of Regulatory Guide 1.52 (Ref. 5) for appropriate credit to be given for iodine removal by the filters. The doses at the nearest exclusion area boundary and LPZ outer boundary are calculated using appropriate assumptions and methods as described in Appendix A to SRP Section 15.6.5.

The doses calculated by the staff are reported in the dose table of the section, "Radiological Consequences of a LOCA," which is prepared in accordance with SRP Section 15.6.5, Appendix A.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information for the staff to perform an independent calculation of the thyroid and whole-body doses due to leakage from ESF components outside containment as the fission

product release path. The calculated doses are reported in the Safety Evaluation Report (SER) in Table 15.__ under SER Section 15._____, "LOCA Radiological Consequences," in accordance with SRP Section 15.6.5, Appendix A. The same SER section will also include the staff's findings with respect to the total calculated doses from all release paths and with respect to the acceptability of the exclusion area and low population zone boundaries on the basis of the total calculated doses in accordance with the guideline values of 10 CFR Part 100.

Following the summary section on the total radiological consequences, separate SER subsections will present the staff's evaluation and finding for each specific fission product release path. For the ESF component leakage path reviewed under this SRP Section 15.6.5, Appendix B, the staff's independent review and calculations should support a conclusion of the following type:

> The radiological consequences resulting from leakage from ESF components located outside containment following the hypothetical design basis loss-of-coolant accident were evaluated. The staff reviewed the applicant's analysis and has performed independent calculations. These calculations are based on conservative assumptions. The fission product source term in the leakage meets the guidelines of Regulatory Guide 1.7. The atmospheric dispersion characteristics (X/Q values) used in the calculations are those stated in Section 2.3 of this report.
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> The results of the calculation are reported in Table 15.___. The contribution of the ESF leakage doses to the total calculated radiological consequences of the LOCA is evaluated in Section 15._____.

V. IMPLEMENTATION

The following provides guidance to applicants and licensees regarding the staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

1. Regulatory Guide 1.7, "Control of Combustible Gas Concentrations in Containment Following a Loss-of-Coolant Accident."

2. 10 CFR Part 100, § 100.11, "Determination of Exclusion Area Low Population Zone and Population Center Distance."

3. Regulatory Guide 1.3, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Boiling Water Reactors."

4. Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors."

5. Regulatory Guide 1.52, "Design, Testing, and Maintenance Criteria for Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants."